SHORT RESUME/ SYNOPSIS OF Ph.D. TOPIC

Entitled

"MORPHO-REGULATORY EFFECTS OF COMMERCIAL NANO-CELLULOSE ON COURTSHIP BEHAVIOURAL DYNAMICS OF BETTA FISH *Betta splendens* (Regan, 1910)."

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"MORPHO-REGULATORY EFFECTS OF COMMERCIAL NANO-CELLULOSE ON COURTSHIP BEHAVIOURAL DYNAMICS OF BETTA FISH *Betta splendens* (Regan, 1910)."

1. A BRIEF RESUME OF PROPOSED WORK / PROBLEM:

Popular freshwater fish, Betta Fish (*Betta splendens*), also known as Siamese fighting fish, are recognized by their long, flowing fins and vibrant colours specially in Male Betta Fish which are particularly known for being aggressively possessive and antagonistic toward one another. They are usually kept alone in tanks because of its behavioural patterns and they are labyrinth fish, which are able to breathe atmospheric air through a unique organ known as the labyrinth organ, they can live in low-oxygen settings.

Aquaculture, ecology, and biology are three areas where nanotechnology is becoming more and more important. Among the nanomaterials, Nano-cellulose especially commercial carboxylated Nano-cellulose is attracting interest because of its environmental sustainability, size that's about nano meters, biocompatibility, and wide range of uses in industries such as food packaging, biomedicine, and water treatment. Nonetheless, little is known about how Nano-cellulose affects aquatic habitats, particularly ornamental fish behaviour Gopi, S., & Kumar, D. S. (2014).

Assessing the various environmental impacts associated with aquaculture's use of Nano-cellulose and their potential uses for enhancing water quality or health in the breeding of ornamental fish requires an understanding of how commercial Nano-cellulose specially carboxylated Nano-cellulose affects fish behaviour. In regard to this, the current study has been set up to examine Betta Fish and its courtship behaviour in substantial detail, including:

- Evaluation of changes in water quality.
- Morpho-regulatory effects of Nano-cellulose.
- Changes in morphology of *Betta splendens*.
- Courtship dynamics and Sexual selection of *Betta splendens.*
- Morphometric analysis of *Betta splendens.*
- Immunological and Histological changes of *Betta splendens.*

2. INTRODUCTION TO PROPOSED RESEARCH TOPIC:

As nanoparticles have special qualities and a wide range of uses, their integration into aquaculture has transformed these sectors. It is suggested that the use of nanomaterials in aquaculture will boost fish development, better the water's quality, and advance aquatic health in general Aingaran, K., Ravindran, R., & Sampath, K. (2017). However, little is known about how nanomaterials affect aquatic organisms' morphology, behaviour, and ability to reproduce. Among the various kinds of nanomaterials, Nano-cellulose which is made from natural cellulose has drawn a lot of interest due to its great mechanical strength, biocompatibility, and environmental friendliness. Among its many uses are environmental remediation and water filtering. Nano-cellulose is a multipurpose material. Whether done so on purpose or accidentally, its introduction into aquatic

systems may result in interactions with a variety of creatures, including fish and recognizing their relationships with nano materials Ebeling, A. W., & Hemdal, J. F. (2012).

The Siamese fighting fish, or *Betta splendens*, is a model organism of choice for researching behavioural and reproductive responses to environmental changes because of its distinctive reproductive methods, remarkable morphological traits, and well-documented courtship behaviours. The elaborate and regulated courtship behaviour of Betta Fish is widely recognized. The male builds a bubble nest during courtship, and they eventually mate and spawn. Reproductive success can be directly impacted by any disturbance to this complex process. It is crucial to comprehend whether the usage of nanomaterials, like as carboxylated Nano-cellulose, in aquatic habitats can affect these crucial behaviours in attractive species like *Betta splendens*, given their expanding application in a variety of industries.

The aquaculture practices give *Betta splendens* and it provide a number of economic advantages, especially in the rapidly expanding global ornamental fish market. The morpho-regulatory effects of Nano-cellulose on Betta Fish courtship behaviour can take several forms, such as morphological modifications, stress reactions, or water quality changes. The fish's ability to recognize and successfully court a partner depends on their ability to detect visuals, which Nano-cellulose particles may interact with and impact. Furthermore, the external morphology of fish, including its colour and fin shape, which are essential for sexual selection, may be regulated by commercial Nano-cellulose. Any morphological changes brought on by exposure to Nano-cellulose could have an immediate impact on the success of mating and the quantity of offspring produced, as Betta Fish rely on their vivid colours and huge fins during courtship displays.

3. SURVEY OR REVIEW OF LITERATURE AND DEVELOPMENT IN THE RELEVANT SUBJECT:

Aquaculture is one of the many areas where nanotechnology has shown to be a critical tool for increasing productivity. Nanomaterials have been investigated for their potential to enhance fish health, water quality, feed efficiency, and disease management because of their distinct physical and chemical characteristics at the nanoscale. But questions have been raised about their potential effects on biology and the environment Agues-Barbosa T, Andrade PVC, Silva PF, Moura CdA, Galvão NL, Freire FAM et al (2022).

The effects of nanomaterials, including nano-cellulose, on aquatic species have been the subject of recent research, which has shown various outcomes. The biodegradable and biocompatible substance known as Nano-cellulose, which is generated from plant fibres, has drawn interest because of its impact on biological systems and possible uses in environmental cleanup. But little is known about how Nano-cellulose affects fish behaviour, especially when it comes to mating and reproduction. *Betta splendens*, the Siamese fighting fish, is well-known for its multiple courtship activities, brilliant colours, and territorial action. In order to attract females, males engage in complicated activities like fin flaring, bubble nest construction, and intricate body movements. However, the environment, and the fish's general health all play a major role in controlling these

behaviours. These courtship behaviours could be affected by any environmental or chemical changes in the water, which could either increase or decrease the success of reproduction.

considering their tiny size, Nano-cellulose in which the size of one single particle is about nano meters that can readily pass through biological membranes, interact with cellular structures, and induce oxidative stress, all of which have the potential to change fish shape and behaviour. According to research by Handy et al. (2008) on the behavioural toxicity of several nanomaterials in fish, extended exposure to these materials may interfere with neurochemical processes, which may change a fish's behaviour in terms of aggression, social interaction, and reproduction. The stability, dispersion, and interaction potential of nano-cellulose with other particles and living things all affect how it behaves in water. The potential of nano-cellulose in water filtering systems has been investigated by studies by Fahim et al. (2015) and Xu et al. (2019), which have demonstrated that it can bind to a variety of organic chemicals and contaminants. This interaction may change the chemical makeup of the water in regulated aquaculture environments, which could affect fish's utilization of sensory cues for territorial displays and mating selection.

4. OBJECTIVES OF THE RESEARCH AND PROPOSED HYPOTHESIS:

The objectives of the study are to:

1. The Collection of Betta Fish, *Betta splendens* from the Reputed local ornamental fish shops/stores of Latur city market.
2. To study the Effect of commercial Nano-cellulose on the physico-chemical parameters of the aquarium.
3. To study the Aggression, colouration changes, feeding behaviours, and swimming patterns by the influence of commercial Nano-cellulose in *Betta splendens*.
4. To Study the Morphometric analysis of *Betta splendens*.
5. To study the effects of commercial Carboxylated Nano-cellulose on courtship behavioural dynamics and sexual selection preferences in *Betta splendens*.
6. To study the courtship behavioural outcomes influenced by commercial Nano-cellulose on Flare displays, Bubble nest formation, chasing and nudging patterns, Embrace and Egg collection in *Betta splendens.*
7. To study the Immunological changes in *Betta splendens*.
8. To analyse the histological changes in fin patterns of *Betta splendens*.

5. METHODOLOGY TO BE USED AND ADOPTED:

Methodologies to be used are mentioned as follows:

1. Betta Fish *Betta splendens* will be collected from various reputable local aquarium shops/stores specializing in ornamental fish from the latur city market Maharashtra.

2. To Evaluate and analyse of the water quality and effect of commercial Nano-cellulose on water quality of the aquarium will be carried out by standard protocol of physico-chemical parameters under controlled conditions.

3. To study the morphological changes and growth will be analysed by the morphometric analysis under controlled conditions by standard protocol, observation and visual recording.

4. To study the Aggression, colouration changes, feeding behaviours, swimming patterns, changes in courtship behavioural patterns and sexual selection are analysed by using the photographic documentation, capturing images and visual recordings.

5. The immunological analysis of commercial corboxylated Nano-cellulose profile in fish immunological changes and detection of antibodies, can be performed by using immune technologies such as ELISA (Enzyme Linked Immunosorbent Assay).

6. The morphological patterns of fin and structure can be identified, observed and compared by using electron microscopy techniques such as SEM (Scanning Electron Microscope).

7. To study the enhancement and changes in fin (especially in Male *Betta splendens*), tissue structure and morphology of the fin can be observed and studied by using the histological methodologies such as microtome for better understating.

8. To understand the effect Commercial carboxylated Nano-cellulose, it will be buy/collected from the reputed pharmaceutical shop/store and to understand its significant activity it will be analysed by using ultraviolet-visible Spectroscopy.

STUDY AREA: Betta Fish *Betta splendens* will be collected from various reputable local aquarium shops/stores specializing in ornamental fish from the Latur city market Maharashtra.

6. IMPORTANCE OF STUDY:

International Status: A study by explored the use of nanocellulose as a bio-sustainable material in aquatic environments. It showed that nanocellulose-based compounds can interact with aquatic organisms, altering their behavior and physiology. The study suggests that nanocellulose can be used as a potential biomaterial in environmental monitoring and species behavior studies, making it relevant for your research on *b*, a species sensitive to environmental changes Aingaran, K., Ravindran, R., & Sampath, K. (2017).

Betta splendens is an important ornamental fish in various countries in the world. Its rank third in ornamental fish industry and being one of the most popular species due to its attractive colour patterns and fin verities worldwide *Betta splendens* has a very prominent role in ornamental fish industry across the world Betta Fish Care. (2020, July 10). The study found that nanomaterials can significantly alter the locomotion, feeding, and social interactions of fish. This is particularly pertinent for your research as it highlights the potential for nanocellulose to impact courtship behavior in fish species, possibly due to changes in sensory perception or neurological pathways Giberson, R. T., & Demaree, R. S. (2016).

The study explored how environmental factors, including water quality and presence of foreign substances, influence courtship rituals. Although the study didn't focus on nanomaterials, it provides a foundation for examining how external agents, like

nanocellulose, might affect courtship behavior in *Betta splendens* Gonçalves, S., & Oliveira, R. F. (2011).

National Status: Apart from its culture value globally, *Betta splendens* has emerged as a prominent species in ornamental fish in aquaculture. These species have also significant part of the aquarium trade, generating revenue. The research highlighted how nanomaterials, particularly cellulose-based nanoparticles, can influence aquatic organism's behavior and Health Benitez, A. J., Walther, A. (2017). While the study focused on general environmental impact, it suggests that commercial Nano-cellulose could affect the physiology and behavior of freshwater species like *Betta splendens*. They are farmed for ornamental culture purpose, supporting local economies. They are also use in scientific research particularly in physiological studies.

Regional Status: The outcomes of this study will be new for the Regional area and the researcher because there hasn't been any previous research in the selected study area on the study of morpho-regulatory effect of commercial carboxylated Nano-cellulose on courtship behavioural dynamics of Betta Fish *Betta splendens*.

Scope/Significance of study: The proposed study will offer an understanding of the patterns of courtship behavioural dynamics of *Betta splendens.* study could lead to better management practices in aquaculture, ensuring that the use of commercial carboxylated Nano-cellulose in changes of fish morphological development and behaviour patterns. This can improve the sustainability and efficiency of aquaculture practices with the improvement in economical purpose. This study will also enable us to explore different ways and diverse applications of aquaculture and conservation of *Betta splendens* in the district.

7. PROPOSED WORK PLAN WITH A TENTATIVE CHAPTER SCHEME:

The work plan of the proposed study can be summarised into following chapters respectively-

1. Introduction.
2. Review of Literature.
3. Material and Methods.
4. Study of Physico-chemical Parameters of Water during Study Period.
5. Changes in Morphological and Behavioural patterns of *Betta splendens.*
6. Sexual selection and Courtship behavioural dynamics of *Betta splendens.*
7. Study of Histological and immunological changes of *Betta splendens*.
8. Result and Discussion.
9. Summery and Conclusion.
10. Bibliography.

8. PROPOSED WORK PLAN/ FORMULATION AND STRUCTURE OF STUDY:

- **First Year-**The Survey, review of literature and the study of materials and methodology which are appropriate to use and visit to various ornamental fish stores/shop for the collection of *Betta splendens* from Latur city market.

- **Second Year-**The study of Morphometric measurements, physico-chemical parameters, morphological changes, and courtship behavioural dynamics in *Betta splendens.* Immunological and histological analysis of commercial Nano-cellulose on *Betta splendens* under controlled conditions.

- **Third Year-**The collection of the visual recordings and statistical data, analysis of the statistical data, publication of research papers, writing Thesis and submission of Thesis.

9. EXPECTED OUTCOME:

From the proposed study, *Betta splendens* is expected and used to analyse the effect of commercial carboxylated *Nano-cellulose* on Changes in morphological development, courtship behavioural dynamics, changes in Sexual selection and mating patterns which can be utilised in diverse ways to serve human welfare and economic upgrade in ornamental fish culture practices and industries in India facing the problems of breeding challenges and population growth *Betta splendens*.

Research in courtship behaviour can generate new knowledge about changes in courtship behavioural dynamics and breeding patterns with respect to commercial Nano-cellulose on *Betta splendens.* The study courtship behaviour uses to solve the problems related to reproductive patterns and failure in proper breeding, can help to attain the expected yield in ornamental fish culture for enhancement in population, conservation and economic upgrade.

The direction of this research work can be adjusted depending upon the findings from time to time, to attain the best expected result within the schedule.

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